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LOW-ENERGY ION COLLISION STUDIES

The collision of low-energy ions with neutral targets can provide, in addition to photoionization and electron ionization, yet another source of atmospheric, interplanetary and stellar electrons. The ion can penetrate into a dense medium such as the Earth's upper stratosphere or Jovian atmosphere and generate in situ a "hot stream" of energetic electrons along its path. The electrons may excite and ionize the component gases, slow down, and then attach or recombine.

With a newly designed crossed-beam apparatus, JPL researchers detected large currents of low-energy electrons in collisions of singly charged helium and magnesium ions with neutral neon, argon, hydrogen, nitrogen, and carbon monoxide. Large differential cross sections -- of the order of 0.1 square angstrom per steradian -- were measured in each system by comparing the secondary electron emission signal with elastic electron scattering signal from the neutral target. The combination of large cross section and low (0-50 electron volts) secondary electron energy means that rates of subsequent excitation, ionization and dissociation of the component gases will be significant.

Systems in which the secondary electron production can be important include the effect of solar wind protons on nitrogen and oxygen in the Earth's atmosphere; protons on carbon monoxide and carbon dioxide on the Venusian and Martian atmospheres; and protons, helium, oxygen, and sulfur ions in the Jupiter-Io system. In the Earth's atmosphere, the production of secondary electrons enhance the familiar Earth's auroral and night-sky emissions. On Venus and Mars, the excitation of CO and CO_2 will be enhanced, leading to increased optical emission from the molecules or their dissociation products, and to increased ionization of the CO and CO_2.

Interactions in the Jupiter-Io system are both complex and fascinating. Protons, sulfur, and oxygen ions can spiral into the polar regions of Jupiter, giving rise to a "hydrogen aurora" (analogous to the Earth's electron-N_2 aurora) either by direct ion-H_2 collision or via the secondary electron-H_2 path. Similar interactions can proceed through the strong accelerating electric fields present in the Jupiter-Io flux tube. Efforts are currently under way to generate beams of negative ions and sulfur ions (SII) to aid in the understanding of the Jupiter-Io system.

Figure (opposite page): Top view of the crossed-beam apparatus. Ions are generated in the lower right-hand section of beam tube, then velocity-analyzed, accelerated, magnetically deflected, and focused into the scattering center (circular tank near upper left corner). There they are crossed with the neutral beam, and emitted secondary electrons detected. Electronic racks in the background are vacuum gauge and pump control devices (left rack), data collection system (center rack), and ion/electron beam focusing potentiometers (right rack).